AB-20 - Paper

CBT Data /Knowledge Acquisition: Using Knowledge Objects to Prototype Courseware

Daniel J. Muraida, Ph.D.
International Horizons Unlimited San Antonio, Texas 78229

Gary R. Grimes, M.S.
Metrica, Inc. San Antonio, Texas

Saul B. Wilen, M.D.
Medical Horizons Unlimited San Antonio, Texas

Introduction

One of the major factors underlying the considerable initial costs of CBT development is the time required of specialists: Programmers, instructional designers, authors, and subject matter experts (SMEs). The SME occupies a pivotal role in the success or failure of any instructional design project. Ideally the SME can save the developers vital production time when he or she provides them annotated or structured documentation that shows how concepts and skills fit together in a given piece of curriculum (Greer, 1991). Although knowledge acquisition has long been recognized as a linchpin process in the development of courseware, the process for collecting the vital content data has been based primarily on unstructured interviews and focus groups which often result in unclearly specified or misspecified requirements (Greer, 1991). The following is an approach to knowledge acquisition that will reduce the time required of an SME, while making that time spent more focused and useful for the production process.

Knowledge acquisition as conceptualized here is based on instructional design research that has successfully used an object-oriented view of the design process (Gonzalez and Vavik, 1994; Merrill, 1997). The subject matter knowledge of an SME is viewed as structured content that can be organized into a pedagogical structure, that will translate into instructional delivery decisions. Knowledge acquisition is further viewed as an early step in an iterative instructional design process that minimizes risk for the designers as well as the client. We find that a courseware engineering model that emphasizes rapid prototyping (Goodyear, 1994) is most compatible with our views of the instructional design process as inherently iterative (Tennyson, 1997).

Rapid Prototyping Approach to Courseware Production

Until six or eight years ago courseware was primarily a process that required the client(s) to endorse a design specification before it could be implemented. Yet problems often arose with this arrangement because the client was often not clear about his or her instructional needs, or had difficulty in understanding the developer's interpretation of those needs as set forth in the requirements. Because of the prohibitively expensive results of building something that the client doesn't

want, the rapid prototyping approach emerged. The focus of the rapid prototyping approach is risk reduction . It consists of a series of iterations through a sequence that includes specification, design, implementation, and review, through which the client and the developers make increasingly accurate approximations to the desired outcome (Cooke, 1994;Goodyear,1997).

Our approach to knowledge acquisition is designed to be a component of a rapid prototyping process. More specifically we consider our approach to be consistent with Boehm's (1988) spiral model of rapid prototyping. This means that the when we collect information on lesson subject matter from the SME we are in a continuous cycle through four successive activities :Risk assessment, implementation, refinement, and integrity checking. Viewed in the most general terms we begin by asking questions that assess the

uncertainties that surround clients' requirements, and the costs of making implementation mistakes. The initial implementation of the prototype focuses on those aspects that have the highest risk and cost of misspecification.. The following activity is refinement, targeting the parts of the prototype that still retain the high risks and costs. Refinement focuses on making the prototype more concrete and specific. The next identifiable stage is when the prototype is refined to the point where it can be checked for compliance with the clients' current understanding of the requirements. Subsequently the products of this refinement process are checked to determine whether they are ready for integration.

Representing Knowledge for Prototype Instructional Designs

Our view of knowledge representation is based on the instructional design research of Merrill(1997) and Tennyson (1997). According to the rapid prototyping approach to courseware development, the knowledge representation of the course content can be revisited, but for specific purposes dictated by a review process that minimizes costs. The instructional design approaches of Merrill and Tennyson recognize the iterative nature of the instructional design cycle, including the knowledge acquisition phase.

Although Merrill's theorizations and models of instructional design tend to be abstract, they provide a highly flexible method of explaining how the structure of knowledge can be coupled to the structure of efficient and effective instruction. Borrowing the concept of an object from artificial intelligence, Merrill defined the concept of a knowledge object as a set of elements, referred to as a frame. The term frame comes from an analogy to a single frame in a film (Minsky, 1974). The concept is that frames have an internal structure consisting of slots (that can have different values) and by virtue of similarities in their internal structure they are related to other frames. Just as certain frames of a film are related because they contain similar elements (e.g., location, themes) that could be instances of a common class or subclass, so knowledge frames can be related, and more specifically, so can content for instructional purposes.

Merrill postulates four basic kinds of instructional design knowledge frames:

Entities, activities, processes and properties. Entities are essentially things that qualify as nouns. Activities are sets of related actions that are performed by a learner. Processes are sets of related actions that take place without the participation of the learner. Properties are qualities or quantities that are associated with entities, activities, or processes. Relationships among frames are viewed as elaborations that comprise a frame network. The elaborations of this network comprise the relationships among the knowledge objects (Merrill, 1997). Merrill proposes three basic ways in which those objects can be related: They can be related via a component relationship, i.e., a relationship that denotes that something is part of a larger structure. They can be linked by an abstraction relationship. This means that an entity, activity or process could be viewed as a subclass or superclass of other entities, activities or processes. They can also be linked by meaningful connections called associations. An example of an association link would be the inclusion of information regarding the power requirements for a desktop computer as part of the total information comprising a lesson on the parts of the computer.

How does this approach translate into more efficient and cost effective knowledge acquisition? Employed within a rapid prototyping approach to instructional design an object-oriented knowledge acquisition method uses knowledge frames or objects and their elaborations as the template for the types of questions that will be presented to the SME. In essence, the types of information are to be obtained from the SME include The applications and appropriateness of this content to the specified student characteristics; the application of this content to the specific instructional environment; and the accuracy and clarity of this instructional content.

Current Use of Knowledge Objects

At present we employ a draft protocol to implement our approach. Data is collected on student characteristics, instructional settings, and content structure. The protocol requests the following applications of the content be addressed by the SME relating to the audience: Geographic location, age, need for motivation, skill levels, individual cognitive ability differences, and learning style. Instructional setting information consists of the following: Individual versus type of group-based instruction; instructor led, automated, or a combination of both; distant versus co-located. Instructional content is captured through a series of items that uses questions based on the combination of knowledge frames with elaboration types to determine the kind of knowledge that needs to be learned.

As An Example:

An opening query would ask the following: How would you categorize what you plan to teach: (a) A device, object, creature, person, place or symbol; or (b) Actions to be performed by a learner; or (c) Actions that do not involve the learner". Assuming that the SME responds that s(he) wishes to teach a process (option b), such as learning to drive a manual transmission vehicle, the follow up question might take the following form(s): "What parts of this process do you wish to

teach?"; "Is this a general process or particular to one type of vehicle?".

Answers to the protocol provide the initial structure for the instructional designers to identify important learner and setting variables, instructional goals, learning objectives, and instructional strategies. How does the process of answering a sequence of questions provide all that information? It does so by virtue of the knowledge frames. If the draft protocol calls for all the data mentioned above, then an example of the answers to just that short query would be as follows:

Student Characteristics

Geographic Location: Southwestern US; Inner city school district

Age: 15-17

Motivational Level: High (Students require little encouragement)

Skill Level: Low (Fewer than 20% have experience with manual transmission)

Individual Cognitive Ability Differences (Minor; Standardized scores generally Homogeneous)

Learning Style(External control)

Instructional Setting

Individual instruction

Automated

Co-located instruction

Instructional Content

Knowledge Frame: Activity – Actions to be performed by a learner

Elaboration: An abstraction relationship – General method of using a stick shift transmission in sedans

What have we gleaned at this point? The students are from an inner city learning environment, with little prior manual transmission experience, but they are motivated to learn the skill. Moreover, they are generally homogeneous in terms of cognitive ability, and they learn more readily with directive instruction. With regard to the planned instructional setting, it is expected that the students will learn the use of a manual transmission individually, from courseware. This information is rather easy to obtain, given that the protocol provides explanations of technical

terms such as cognitive ability

and learning style. What is difficult to obtain is the content structure and the potential links to instructional strategies and delivery methods (media), but that is exactly the kind of information that a knowledge object based protocol elicits. Given that the content to be learned is an activity, and it is a generic activity, appropriate instructional strategies can be identified through the application of instructional models that address the identified learning requirements. In this example the generic activity could be taught by a series of interactions between student and instructional system known as an execution transaction (Merrill, 1997) or as an intellectual (procedural) skill (Gagne, 1993), just to name two of the available instructional strategies. This technique is in development. Structured interviews are the first step for automated knowledge elicitation processes, especially if combined with other techniques(Cooke, 1994; Shute, Torreano, & Willis, 1998). The major problem in automating a knowledge elicitation method for use with courseware authoring systems lies in the interpretability of the data the authoring system receives. Recent attempts to automate knowledge elicitation techniques have proved encouraging (Shute, et al , 1998), but lacking is a language that can address the many different kinds of knowledge types while linking them to their corresponding instructional and delivery strategies, irrespective of authoring language. It is our contention that knowledge objects provide the bridge to authoring the appropriate strategies because they elicit content knowledge in terms that can be manipulated in most existing authoring languages. These instructional strategies can be organized, selected, and implemented by couching them in an object-oriented framework. Rapid prototyping facilitates the transmission of high quality data between the SME and the designers. Data quality will be enhanced by more accurate initial assessments and implementations, and refinements, resulting in CBT that embodies the instructional environment that meets the standards for both clients and designers. Ongoing evaluations that examine the versions of this object oriented approach to instructional knowledge acquisition will define long term applications for CBT development.

REFERENCES

Boehm, B (1988) A spiral model of software development and enhancement. IEEE Computer, 21 , 61-72

Cooke, N.J.(1994) Varieties of knowledge elicitation techniques. International Journal of Human-Computer Studies, 41, 801-849.

Gonzalez, J. J., and Vavik, L. (1994) Experiences and prospects derived from the Norwegian R&D project in the automation of instructional design. In R.D.

Tennyson (ed.), Automating Instructional Design, Development, and Delivery, Berlin, Springer-Verlag.

Gagne, R.M. (1993) Computer-based instructional guidance. In J.M.Spector, M.C.

Polson, and D.J. Muraida, (eds) Automating Instructional Design: Concepts and Issues. Englewood Cliffs, NJ: Educational Technology Publications.

Goodyear, P. (1994) Foundations for courseware engineering. In R.D. Tennyson, (ed.), Automating Instructional Design, Development, and Delivery. Berlin, Springer-Verlag.

Goodyear, P. (1997)Instructional design environments: Methods and tools for the design of complex instructional systems. In S. Dijkstra, N. Seel, F.Schott, and R.D. Tennyson, (eds) Instructional Design: International Perspectives (Vol. 2), Mahwah, NJ: Lawrence Erlbaum Associates.

Greer, M. (1991) Organising and managing the ID process. In L.J. Briggs, K.L., Gustafson, and M.H. Tillman, (eds), Instructional Design: Principles and Applications. Englewood Cliffs, NJ: Educational Technology Publications.

Merrill, M.D. (1997) Instructional transaction theory: An instructional design model based on knowledge objects. In R.D. Tennyson, F. Schott, N. Seel, and S. Dijkstra (eds), Instructional Design International Perspectives (Vol 1), Mahwah, NJ: Lawrence Erlbaum Associates.

Minsky, M, (1974) A framework for representing knowledge. Artificial Intelligence Memo, 306, MIT AI Lab

Shute, V.J., Torreano, L.A., and Willis, R.E.(1998) DNA: Uncorking the bottleneck in Knowledge elicitation and organization. Proceedings of the Fourth International Conference, ITS '98. San Antonio, TX, USA. August.

Tennyson, R.D., (1997) A system dynamics approach to instructional systems development. In R.D. Tennyson, F. Schott, N. Seel, and S, Dijkstra, (eds), Instructional Design: International Perspectives. Mahwah, NJ: Lawrence Erlbaum Associates.

INTERNET DOCUMENT INFORMATION FORM

A . Report Title: CBT Data/Knowledge Acquisition: Using Knowledge Objects to Prototype Courseware

B. DATE Report Downloaded From the Internet 4/21/99

C. Report's Point of Contact: (Name, Organization, Address, Office Symbol, & Ph #): Navy Education and Training Professional Development and Technology Center Navy Advancement Center Dept Dr. Grover Diesel, (850) 452-1815 6490 Saufley Field Road Pensacola, FL 32509-5237

D. Currently Applicable Classification Level: Unclassified

E. Distribution Statement A: Approved for Public Release

F. The foregoing information was compiled and provided by: DTIC-OCA, Initials: VM_ **Preparation Date**: 4/22/99__

The foregoing information should exactly correspond to the Title, Report Number, and the Date on the accompanying report document. If there are mismatches, or other questions, contact the above OCA Representative for resolution.